

PATENT APPLICATION

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TITLE OF THE INVENTION

5 Hybrid Catamaran Air Cushion Ship

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10 CROSS-REFERENCE TO RELATED APPLICATIONS

Priority of US Provisional Patent Application Serial No. 60/410,131, filed 12
September 2002, incorporated herein by reference, is hereby claimed.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR
DEVELOPMENT

15 Not applicable

REFERENCE TO A MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

1. Field of the Invention

20 The present invention relates to catamaran air cushion ships. More
particularly, the present invention relates to an improved surface effect ship or air
cushion ship with a catamaran hull that enables both low and high speeds with
improved efficiency.

2. General Background of the Invention

25 The typical side hull geometry that has been employed by surface effect
ships is a prismatic, hard-chine planing hull. These types of hulls are inefficient at
developing lift and have very high wave making drag characteristics when the ship
is off cushion in the displacement mode. Their primary advantages comes from their
ease of production and their tendency to introduce a degree of dynamic stability at
30 high speeds.

In general, catamaran air cushion ships are known. Examples are listed in
the following table. The table also lists some propeller related art.

TABLE 1

	Patent		Issue
	<u>Number</u>	<u>Title</u>	<u>Date</u>
	1,976,046	Waterfoil	10/9/1934
5	2,405,115	Floating Structure	08/6/1946
	3,065,723	Supercavitating Hydrofoils	11/27/1962
	3,077,173	Base Ventilated Hydrofoil	02/12/1963
	3,621,932	Gas-Cushion Vehicles	11/23/1971
	3,917,022	Twin Cushion Surface Effect	
10		Vehicle	11/4/1975
	3,987,865	Gas-Cushion Vehicle Skirt	10/26/1976
	4,469,334	Sealing System For The Air	
		Cushion Of An Air-Cushion	
		Vessel	09/4/1984
15	4,489,667	Surface Effect Ship Seals	12/25/1984
	4,506,618	Propeller And Keel	
		Arrangement For Surface	
		Effect Ships	03/26/1985
	4,535,712	Variable Air Cushion Mode	
20		Vehicle	08/20/1985
	4,543,901	Surface Effect Ship Air	
		Cushion Seal System	10/1/1985
	4,646,866	Surface Effect Type, Side	
		Keel Vessel Fitted With An	
25		Improved Forward Buoyancy	
		Cushion Seal Apparatus	03/3/1987
	4,660,492	Catamaran Air Cushion Water	
		Vehicle	04/28/1987
	4,708,077	Hull Shapes For Surface	
30		Effect Ship With Side Walls	
		And Two Modes Of	
		Operation	11/24/1987

	4,767,367	Integrated Combination	
		Propeller Drive Shaft	
		Fairing and Water Intake	
		Sea Chest Arrangement, For	
5		High Speed Operating Marine	
		Craft	08/30/1988
	5,711,494	Aero-Hydroglider	01/27/1998
	5,934,215	Stabilized Air Cushioned	
		Marine Vehicle	08/10/1999
10	6,293,216	Surface Effect Ship (SES)	
		Hull Configuration Having	
		Improved High Speed	
		Performance and Handling	
		Characteristics	09/25/2001
15	6,439,148	Low-Drag, High-Speed Ship	08/27/2002

Incorporated herein by reference are US Patent Nos. 4,767,367; 6,293,216; and 6,439,148. These three patents relate generally to surface effect ships or hovercraft.

BRIEF SUMMARY OF THE INVENTION

20 The present invention comprises a vessel designed to operate as both a catamaran and an air cushion vessel. This hybrid catamaran air cushion ship has several advantages over previous air cushion and surface effect ship designs. It will be able to efficiently travel at low speeds (Froude number (Fn) = about 0-0.3) in the catamaran or displacement mode. It will also have the ability to operate in the air
25 cushion or dynamically supported mode at high speeds (Froude number (Fn) = about 0.3 and greater) and with the ability to operate at all speeds.

It will be able to efficiently travel at low speeds (e.g. about 0 - 20 knots (0-37 km/hour)) in the catamaran or displacement mode. It will also have the ability to operate in the air cushion or dynamically supported mode at high speeds (e.g. about
30 50 knots (93 km/hour) and greater) and with the ability to operate at all speeds. The air cushion can also be used to reduce the ship's already shallow static draft from, for example, approximately five meters to less than one meter. This ability decreases

underwater signatures and has been proven in several full-scale tests to improve survivability in the event of a mine encounter.

This design concept departs from previous surface effect ships in one key area. With very few exceptions, the surface effect vessels built to date have been
5 designed to optimize high speed performance. The vessel of the present invention will capitalize on the strengths of both the air cushion and catamaran types of vessels. It will be able to operate efficiently at high speeds, but will also be able to operate efficiently in the lower speed regime.

This dual mode operation capability will enable the ship to adapt to sea
10 conditions and operate for extended periods without refueling.

The vessel of the present invention features molded catamaran hulls with parabolic waterlines, a flexible, retractable air cushion seal system, an independently powered lift fan (air cushion) system, surface piercing propellers (optionally controllable pitch) and a power plant for each propeller (e.g. combined diesel and
15 gas turbine propulsion system).

Lift air pressure can be generated, for example, by auxiliary gas turbines or diesels. Forward mounted lifting foils will facilitate ride stabilization and load compensation, at high and low speeds. These foils will also be used to generate transverse roll forces to improve high speed maneuvering. Very low speed, quiet
20 maneuvering can be assisted by a retractable, omni-directional thruster unit.

The vessel of the present invention can displace e.g. up to 2000 long tons, but is scalable and may be manifested in lesser or greater displacements. A vessel in this displacement range, can be, for example, approximately 90m in length, with about a 30m beam.

25 The concept of the hybrid catamaran air cushion ship of the present invention combines an improved, specially configured catamaran design with equally viable concepts in air cushion vehicle technology. The craft of the present invention is as efficient as possible for low speed operations while giving it the reduced drag advantages enjoyed by dynamically supported, high speed, air cushion vessels. To
30 accomplish this task effectively, the present invention provides several features.

The side hulls of the present invention are preferably molded (rounded) forms featuring parabolic waterlines and semi-elliptical cross sections (see Figures

6-7). These forms minimize the characteristic wave trains associated with low speeds and have been shown to have superior drag characteristics at both low and high speeds.

The present invention employs small lifting surfaces to provide load
5 compensation, ride control and high-speed stabilization. These surfaces can take the form of two, independently controlled, wing sections mounted port and starboard below the waterline on the side hulls (e.g., inboard and forward). Their primary task is to provide ride control at all speeds but they will also provide high-speed stability, enhancing both directional control and maneuvering.

10 To take full advantage of the low drag side hulls that the vessel of the present invention will possess, flexible air cushion seals (bow and stern) that can be retracted from the water. When the craft is not in the air cushion mode, these seals could cause additional viscous drag and limit maneuverability. The seals can be retracted and stowed above the water level, for example under the wet deck
15 structure. This will reduce drag in the displacement mode, and improve seal life. The seals can preferably be deployed or retracted rapidly and remotely, without manual intervention from the crew.

A hybrid hullform was designed, using slender forms for the sidehulls rather than the long planing bodies used for most surface effect ships. The sidehull depth
20 was set to provide a cross structure (wet deck) clearance (of e.g. two meters) above the water, enabling operation as a catamaran, with some allowance for future weight growth.

The lift system and air cushion seals were designed to provide additional wet deck clearance (of, e.g., five meters) when on-cushion (when the vessel is operated
25 in conjunction with a pressurized air cushion), resulting in a low keel draft (e.g., about one meter) in calm water conditions. Although slightly higher in calm water drag than a conventional surface effect ship (SES), this configuration will operate with essentially the same sidehull wetted area in higher sea states (e.g., waves up to about two meters), and hence will retain performance.

30 The propulsor is preferably designed for high efficiency in both a low speed mode and a high speed mode. Initial studies considered both waterjets and propellers as candidate propulsors. It became apparent that propellers were preferred

as they could offer certain desired performance characteristics across the entire speed range. To be efficient at high speeds, a propeller has to operate in the partially submerged mode to avoid prohibitively high drag from the hub and related support structure. Because of the change in keel immersion as the ship goes from off
5 cushion to on cushion, a stern-mounted propeller can be arranged to naturally operate fully submerged in the catamaran mode and surface piercing in the SES mode.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a further understanding of the nature, objects, and advantages of the
10 present invention, reference should be had to the following detailed description, read in conjunction with the attached drawings which are identified as follows:

Figure 1 is a perspective view of the preferred embodiment of the apparatus of the present invention;

Figure 2 is a side view of the preferred embodiment of the apparatus of the
15 present invention showing the displacement mode;

Figure 3 is a side view of the preferred embodiment of the apparatus of the present invention showing the high speed, planing mode;

Figure 4 is a rear perspective view of the preferred embodiment of the apparatus of the present invention showing the high speed, planing mode;

20 Figure 5 is a sectional view taken along the lines 5-5 of Figure 2;

Figure 6 is a sectional view taken along the lines 6-6 of Figure 5;

Figure 7 is a sectional view taken along the lines 7-7 of Figure 5;

Figure 8 is a sectional view taken along the lines 8-8 of Figure 5;

Figure 9 is a fragmentary perspective view of the preferred embodiment of
25 the apparatus of the present invention illustrating the propulsion system for one of the hulls;

Figure 10 is a front view of the preferred embodiment of the apparatus of the present invention showing the displacement mode; and

Figure 11 is a rear view of the preferred embodiment of the apparatus of the
30 present invention showing the displacement mode.

DETAILED DESCRIPTION OF THE INVENTION

The vessel of the present invention is designed to operate as both a catamaran and air cushion vessel. The hybrid catamaran air cushion ship of the present invention is designated generally by the numeral 10 in Figures 1-4. Vessel 10 has several advantages over previous air cushion and surface effect ship designs. It will be able to efficiently meet the demands of the low speed (Froude number 0 - 0.3) requirements in the catamaran or displacement mode (see first water line, numeral 27 in Figure 2). The vessel 10 of the present invention will also have the ability to operate in the air cushion or dynamically supported mode, (see second water line, numeral 28 in Figure 3) where it will meet the high speed (Froude numbers 0.3 and higher) performance targets and provide the ability to operate in extreme sea states.

Vessel 10 will be able to efficiently meet the demands of the low speed (e.g. 0 - 20 knots (0-37 km/hour)) requirements in the catamaran or displacement mode (see first water line, numeral 27 in Figure 2). The vessel 10 of the present invention will also have the ability to operate in the air cushion or dynamically supported mode, (see second water line, numeral 28 in Figure 3) where it will meet the high speed (e.g. 50 knots (93 km/hour) or higher) performance targets and provide the ability to operate in extreme sea states.

The air cushion can also be used to reduce the ship's static draft (from for example approximately five meters to for example less than one meter). This ability decreases underwater signatures and has been proven in several full-scale tests to improve survivability in the event of a mine encounter.

Hybrid catamaran air cushion ship 10 has a catamaran hull defined by port hull 11 and starboard hull 12. The vessel 10 provides a bow 13 and stern 14. Platform 15 is connected to and spans between the port hull 11 and starboard hull 12. The catamaran hull and platform 15 carry a powered lift fan system (e.g. gas turbine) for forming an air space between hulls 11, 12 and seals 16, 17. Such powered lift fan systems are known in the art.

Each hull 11, 12 can optionally be provided with foil stabilizers 30 (see, e.g., Figures 10 and 11). At bow 13, forward seal 16 can be in the form of a plurality of individual finger seals 25. Such a seal 16 can be seen for example in prior US

Patents 3,621,932; 3,987,865; and 4,646,866, each incorporated herein by reference. Forward seal 16 includes preferably a plurality of between about four and ten (preferably eight) fingers or elements 25. These can be retracted when low speed operation (Figure 2) is required. These fingers 25 can also be used to generate
5 transverse roll forces to improve high speed maneuvering.

An aft seal 17 is provided at stern 14 as shown in Figure 11. The forward and aft seals 16, 17 in combination with the catamaran hulls 11, 12 provide a space that can be pressurized with air for providing an air cushion that supports the ship 10 in a high speed mode shown in Figure 3. In the mode of Figure 3, the second water
10 line 28 extends through the center of rotation of propellers 20, enabling the air cushion ship 10 of the present invention to attain high speeds of for example in excess of 50 knots (93 km/hour) with minimal resistance. Propellers 20 are designed to operate in a surface piercing mode and/or fully wetted mode (where the propellers 20 are typically fully submerged) and can for example be driven by a
15 diesel or a gas turbine power plant or a combined diesel and gas turbine power plant.

In a slow travel mode of for example between about 0 and 20 knots (0 and 37 km/hour), vessel 10 can travel in a displacement mode that is shown in Figure 2. That vessel 10 is in the displacement mode in Figure 2 can be seen by observing first water line 27. In the displacement mode of Figure 2, the propellers 20 are fully
20 submerged as is each of the rudders 23, 24. In the displacement mode of Figure 2, the forward and aft seals 16, 17 can be retracted or removed.

In Figures 5-9, each of the hulls 11, 12 is a smooth hull providing a smooth outer surface that does not have any hard chines. Such a hull construction as shown in Figures 5-9 is very efficient at low speeds. Each of the port hull 11 and starboard
25 hull 12 has a smooth curved bottom 18 and a pair of opposed smooth side walls 19, 21. The side walls 19, 21 include outer side wall 19 and inner side wall 21. The side walls 19, 21 can be generally vertically oriented as shown in Figures 6 and 7. These hulls 11, 12 preferably have parabolic waterlines.

A propeller shaft housing 22 that is tubular in shape can extend from the rear
30 of each of the port and starboard hulls 11, 12 as shown in Figures 2, 3, 8, and 9. Each hull 11, 12 has its own surface piercing propeller 20. Port hull 11 provides port rudder 23. Starboard hull 12 provides starboard rudder 24.

A deck area 26 can be provided that includes a super structure 29. This deck area 26 can provide a hangar, flight deck, and a plurality of hatches to enable numerous uses for the ship. The present invention capitalizes on strengths of both the air cushion and catamaran types of vessels. It is able to operate efficiently at high speeds, but is also able to operate efficiently in the lower speed regime.

The hulls can be made of aluminum, steel, composite materials, or any other suitable material which will be apparent to those of ordinary skill in this art.

The following is a list of suitable parts and materials for the various elements of the preferred embodiment of the present invention.

10	<u>PARTS LIST</u>	
	<u>Parts Number</u>	<u>Description</u>
	10	hybrid catamaran air cushion ship
	11	port hull
	12	starboard hull
15	13	bow
	14	stern
	15	platform
	16	forward seal
	17	aft seal
20	18	curved bottom
	19	outer side wall
	20	propeller
	21	inner side wall
	22	propeller shaft housing
25	23	port rudder
	24	starboard rudder
	25	bow seal element
	26	deck area
	27	first water line (displacement mode)
30	28	second water line (planing mode)
	29	superstructure
	30	foil stabilizer

All measurements disclosed herein are at standard temperature and pressure, at sea level on Earth, unless indicated otherwise.

The foregoing embodiments are presented by way of example only; the scope of the present invention is to be limited only by the following claims.

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